In [3]:
```
pip install pygad
```

```
Requirement already satisfied: pygad in c:\users\manasa\appdata\local\programs\python\python311\lib
\site-packages (3.0.1)
Requirement already satisfied: cloudpickle in c:\users\manasa\appdata\local\programs\python\python3
11\lib\site-packages (from pygad) (2.2.1)
Requirement already satisfied: matplotlib in c:\users\manasa\appdata\local\programs\python\python31
1\lib\site-packages (from pygad) (3.7.1)
Requirement already satisfied: numpy in c:\users\manasa\appdata\local\programs\python\python311\lib
\site-packages (from pygad) (1.24.3)
Requirement already satisfied: contourpy>=1.0.1 in c:\users\manasa\appdata\local\programs\python\py
thon311\lib\site-packages (from matplotlib->pygad) (1.0.7)
Requirement already satisfied: cycler>=0.10 in c:\users\manasa\appdata\local\programs\python\python
311\lib\site-packages (from matplotlib->pygad) (0.11.0)
Requirement already satisfied: fonttools>=4.22.0 in c:\users\manasa\appdata\local\programs\python\p
ython311\lib\site-packages (from matplotlib->pygad) (4.39.4)
Requirement already satisfied: kiwisolver>=1.0.1 in c:\users\manasa\appdata\local\programs\python\p
ython311\lib\site-packages (from matplotlib->pygad) (1.4.4)
Requirement already satisfied: packaging>=20.0 in c:\users\manasa\appdata\local\programs\python\pyt
hon311\lib\site-packages (from matplotlib->pygad) (23.1)
Requirement already satisfied: pillow>=6.2.0 in c:\users\manasa\appdata\local\programs\python\pytho
n311\lib\site-packages (from matplotlib->pygad) (9.5.0)
Requirement already satisfied: pyparsing>=2.3.1 in c:\users\manasa\appdata\local\programs\python\py
thon311\lib\site-packages (from matplotlib->pygad) (3.0.9)
Requirement already satisfied: python-dateutil>=2.7 in c:\users\manasa\appdata\local\programs\pytho
n\python311\lib\site-packages (from matplotlib->pygad) (2.8.2)
Requirement already satisfied: six>=1.5 in c:\users\manasa\appdata\local\programs\python\python311
\lib\site-packages (from python-dateutil>=2.7->matplotlib->pygad) (1.16.0)
Note: you may need to restart the kernel to use updated packages.
```

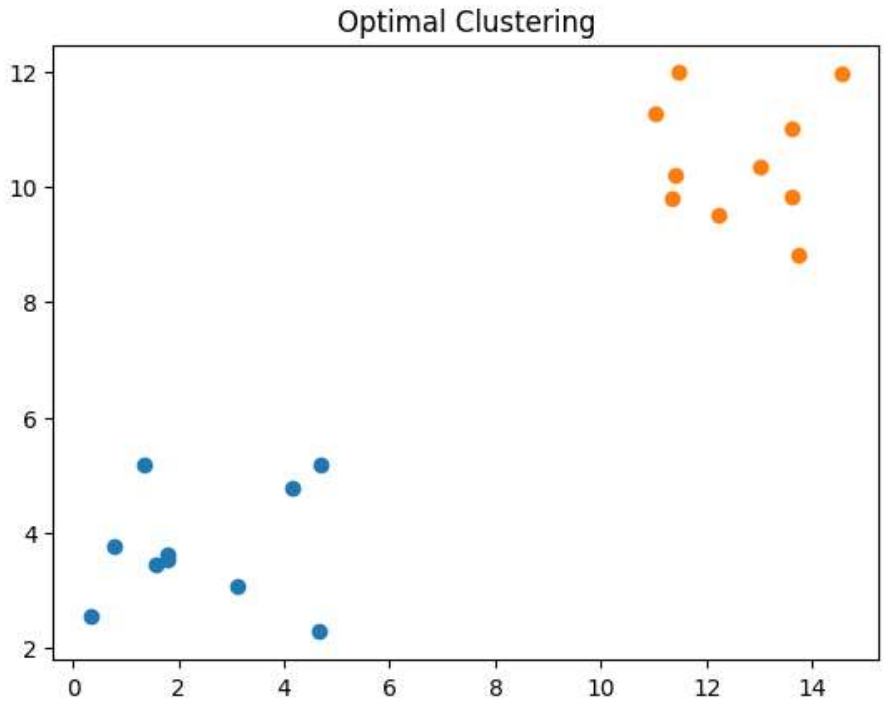
In [4]:
```
import numpy
import matplotlib.pyplot
import pygad
```

In [5]:
```
cluster1_num_samples = 10
cluster1_x1_start = 0
cluster1_x1_end = 5
cluster1_x2_start = 2
cluster1_x2_end = 6
cluster1_x1 = numpy.random.random(size=(cluster1_num_samples))
cluster1_x1 = cluster1_x1 * (cluster1_x1_end - cluster1_x1_start) +cluster1_x1_start
cluster1_x2 = numpy.random.random(size=(cluster1_num_samples))
cluster1_x2 = cluster1_x2 * (cluster1_x2_end - cluster1_x2_start) +cluster1_x2_start
cluster2_num_samples = 10
cluster2_x1_start = 10
cluster2_x1_end = 15
cluster2_x2_start = 8
cluster2_x2_end = 12
cluster2_x1 = numpy.random.random(size=(cluster2_num_samples))
cluster2_x1 = cluster2_x1 * (cluster2_x1_end - cluster2_x1_start) +cluster2_x1_start
cluster2_x2 = numpy.random.random(size=(cluster2_num_samples))
cluster2_x2 = cluster2_x2 * (cluster2_x2_end - cluster2_x2_start) +cluster2_x2_start
```

In [6]:
```
c1 = numpy.array([cluster1_x1, cluster1_x2]).T
c2 = numpy.array([cluster2_x1, cluster2_x2]).T
data = numpy.concatenate((c1, c2), axis=1)
data
```

Out[6]:
```
array([[ 0.79666947,  3.76507174, 13.614769  ,  9.82435548],
       [ 1.34179444,  5.16752524, 13.61663863, 11.00483283],
       [ 0.33787256,  2.54026661, 13.01752885, 10.34212172],
       [ 1.58572323,  3.4610552 , 11.46898319, 11.97582927],
       [ 1.80032974,  3.6164905 , 11.01835247, 11.258206  ],
       [ 4.14587541,  4.76287683, 11.33844188,  9.80990238],
       [ 1.78491526,  3.52001974, 14.55302564, 11.94784466],
       [ 4.69858822,  5.16558713, 11.41947471, 10.18766338],
       [ 4.66373416,  2.2785962 , 13.73390906,  8.82698142],
       [ 3.10983797,  3.05931078, 12.21445934,  9.50747527]])
```

In [7]:
```
matplotlib.pyplot.scatter(cluster1_x1, cluster1_x2)
matplotlib.pyplot.scatter(cluster2_x1, cluster2_x2)
matplotlib.pyplot.title("Optimal Clustering")
matplotlib.pyplot.show()
```



In [8]:
```
def euclidean_distance(X, Y):
    return numpy.sqrt(numpy.sum(numpy.power(X - Y, 2), axis=1))
```

In [9]:
```
def cluster_data(solution, solution_idx):
    global num_cluster, data
    feature_vector_length = data.shape[1]
    all_clusters_dists = []
    cluster_centers = []
    clusters = []
    clusters_sum_dist = []
    for clust_idx in range(num_clusters):
        cluster_centers.append(solution[feature_vector_length*clust_idx:feature_vector_length*(clust
        cluster_center_dists = euclidean_distance(data, cluster_centers[clust_idx+1])
        all_clusters_dists.append(numpy.array(cluster_center_dists))
    cluster_centers = numpy.array(cluster_centers)
    all_clusters_dists = numpy.array(all_clusters_dists)
    cluster_indices = numpy.argmin(all_clusters_dists, axis=0)
    for clust_idx in range(num_clusters):
        clusters.append(numpy.where(cluster_indices ==clust_idx)[0])
        if len(clusters[clust_idx]) == 0:
            clusters_sum_dist.append(0)
        else:
            clusters_sum_dist.append(numpy.sum(all_clusters_dists[clust_idx,clusters[clust_idx]]))
    clusters_sum_dist = numpy.array(clusters_sum_dist)
    return cluster_centers, all_clusters_dists, cluster_indices, clusters,clusters_sum_dist
```

In [10]:
```
def fitness_func(ga_instance,solution, solution_idx):
    _, _, _, _, clusters_sum_dist = cluster_data(solution, solution_idx)
    fitness = 1.0 / (numpy.sum(clusters_sum_dist) + 0.00000001)
    return fitness
```

In [ ]:
```
num_clusters = 2
num_genes = num_clusters * data.shape[1]
ga_instance = pygad.GA(num_generations=100,
                sol_per_pop=10,
                    num_parents_mating=5,
                    init_range_low=-6,
                    init_range_high=20,
                    keep_parents=2,
                    num_genes=num_genes,
                    fitness_func=fitness_func,
                suppress_warnings=True)
ga_instance.run()
```

In [ ]:
```
best_solution, best_solution_fitness, best_solution_idx=ga_instance.best_solution()
print("Best solution is {bs}".format(bs=best_solution))
print("Fitness of the best solution is {bsf}".format(bsf=best_solution_fitness))
print("Best solution found after {gen} generations".format(gen=ga_instance.best_solution_generation)
```

In [ ]:
```
for cluster_idx in range(num_clusters):
    cluster_x = data[clusters[cluster_idx], 0]
    cluster_y = data[clusters[cluster_idx], 1]
matplotlib.pyplot.scatter(cluster_x, cluster_y)
matplotlib.pyplot.scatter(cluster_centers[cluster_idx, 0], cluster_centersmatplotlib.pyplot.title("C
matplotlib.pyplot.show()
```